

PROMOTOR TRANSFERABLE TRAINING
MODULES ON

Arsenic



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Promotor Transferable Training Modules on
Arsenic

Instructor's Guide

Statement by the Authors

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Table of Contents

Arsenic Module.....	5
Additional Resources.....	10
Training Tools.....	11
Supplemental Materials.....	18
Glossary.....	20

Arsenic Module

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Arsenic – Good Element, Bad Chemistry

Module Summary

Arsenic exists in the environment naturally. It can be found in some areas in the geological features (rock formations) in high concentrations. This is particularly true of the southwestern United States and northern Mexico. In this module, *promotores* will learn about arsenic, how it interacts in the environment, and the effects it has on human health.

Learning Objectives

- Gain knowledge about arsenic and its properties.
- Determine the chemical forms of arsenic.
- Acquire information on the many uses of arsenic.
- Define the different human exposure routes.
- Learn the basics of arsenic toxicology.
- Understand methods to decrease exposure to arsenic.

Arsenic Background

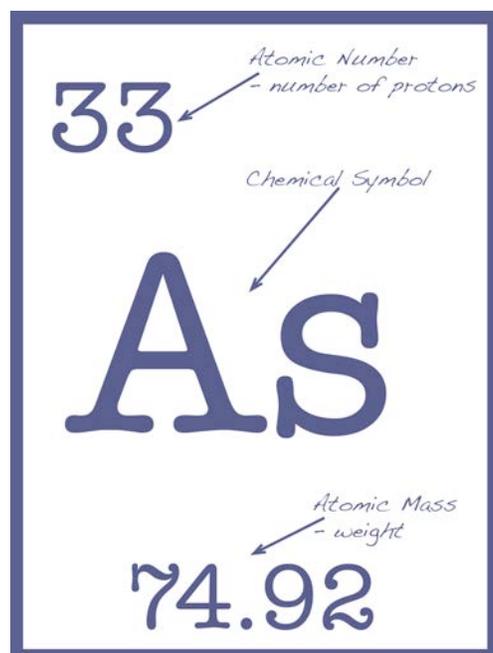


Figure 1. Chemical abbreviation for arsenic along with its atomic number, and atomic mass.

The chemical abbreviation of arsenic is As (Figure 1). It is a solid substance that is naturally found in the Earth's crust. It can be incorporated into soil, dust, water, food, and air particles. Arsenic is an **element**, which is classified as a **semi-metal**. Its pure form is gray colored and it is usually found in combination with other elements (e.g. gold, silver, lead, and copper). It has no odor or taste.

The presence of arsenic can increase due to human activities such as mining* and industrial operations. It can be released into the air and subsequently deposited onto bodies of water and surface soil. In general, arsenic and compounds containing arsenic are very toxic and as a result their use is strictly controlled by health and environmental regulations. There are two different chemical forms: **inorganic** and **organic**. Almost all arsenic is found in the inorganic form and it is what we come across in soil, rocks, groundwater, surface water, and industrial waste. Organic arsenic, on the other hand, can be found in pesticides, animals, plants, and fish.

* Arsenic is associated with the mining of different metals such as copper, silver, and gold. Usually, it is extracted with the bulk material containing both arsenic and metal or it is found as a mineral such as arsenopyrite.

Humans have used arsenic for a very long time. In the past, it was utilized as a fabric dye, beauty treatment, and leather tannin. Common uses of arsenic today are as wood preservatives, agricultural insecticide, cotton defoliants (causes leaves to fall off), as well as in electronic and medicine products. The most current concerns regarding arsenic include natural sources contaminating drinking water and its absorption in some foods (e.g. rice and lettuce) that we may consume.

Either inhaling or ingesting arsenic exposes living organisms to its potential negative effects. The main routes of arsenic exposure in humans are drinking water, dust, and food (Table 1). Inorganic arsenic does not easily penetrate the skin so bathing, laundering, showering, and washing are not concerns when it comes to exposure. Caution should be taken when cooking with water that contains arsenic since it can be absorbed by foods.

Routes of Exposure	Exposure
Drinking Water	<ul style="list-style-type: none"> • Arsenic in soil may be deposited onto bodies of water. • Industrial wastewater containing arsenic can be discharged into waterways. • Runoff from agricultural sites using arsenic based pesticides can enter ground and surface water supplies.
Dust	<ul style="list-style-type: none"> • Air currents can pick up dust with arsenic from mine tailings (mining waste). • Dust may sometimes contain arsenic, especially in areas that it is found in the geology (when it attaches to small particles, it can travel long distances and be suspended in the air for several days). • Dried agricultural and industrial residues that contain arsenic can be blown around. • Smoke from burning oil, coal, wood, gasoline, and tobacco may spread arsenic in the soot.
Food	<ul style="list-style-type: none"> • Seafood, algae, carrots, and rice can contain arsenic when it is absorbed into tissues from the surrounding environment.

Table 1. Outline of the exposures arsenic via water, dust, and food.

An issue important in some environments, such as Arizona and Sonora, is the presence of naturally occurring inorganic arsenic in the groundwater. In these areas, this is considered a type of water contamination. Water that encounters rock formations can dissolve arsenic and carry it into water supplies. The arsenic containing rock formations dissolve because water changes the chemical composition of the rock. In other words, as water travels by the rock formation, it can take with it minerals, metals, and semi-metals.

Arsenic is classified as a known human **carcinogen**. The health effects that result from exposure to arsenic compounds varies depending on route, dose, duration, lifestyle, and genetics (Table 2). Exposure to too much arsenic can result in harmful side effects. Most of the arsenic that enters the body is processed quickly and discharge via the urine (a single dose is discharged in the urine within 1-3 days). Those most susceptible to arsenic toxicity are unborn babies and children. In addition, those who are elderly or have poor diets can also be more susceptible to harmful effects.

Arsenic Exposure	Potential Health Effects
Acute	<ul style="list-style-type: none"> Stomach pain, nausea, vomiting, diarrhea, headache, tired, throat dryness, difficulty urinating, and dizziness
Chronic	<ul style="list-style-type: none"> Skin lesions, skin discoloration, kidney damage, anemia, low blood pressure, headache, weakness, delirium, liver problems, irritation of nose membrane, and cancer of the lungs, skin, and bladder.

Table 2. Summarizes the human health effects in relation to exposure type

Under United States drinking water law, water from public systems must be tested for arsenic. In the U.S. the **maximum contamination level (MCL)** for arsenic that is allowed in drinking water as established by the US Environmental Protection Agency (US EPA) is **10 parts per billion (ppb)**. The MCL is an enforceable drinking water quality standard. It indicates the upper limit of a substance that can be present in public water systems. The US EPA sets this standard by considering how much of the substance may be present without causing adverse human health effects. It is important to highlight that the US EPA only sets these standards for drinking water, and does not regulate bottled water.

In Mexico, the National Water Commission (*Comisión Nacional del Agua – CONAGUA*) has set **25 ppb** as the arsenic limit within drinking water systems. CONAGUA has the authority to enforce this standard while the Federal Legal Office for Environmental Protection (*Procuraduría Federal de Protección al Ambiente*) must take legal action if there are any infractions. Municipal infrastructure authorities and communal land systems (*ejidos*) also are involved in managing drinking water systems at a local level.

Reducing arsenic exposure is important in order to decrease the potential health effects. There are several ways that you can decrease exposure. *Behavior changes, treatment technologies, cleaning*



techniques, and consumer choices are some of the primary ways to diminish exposure. Of course, general information on arsenic and awareness of its presence also is very important. If there is a suspicion that there has been an arsenic intoxication, medical doctors can perform tests to find out. They can either look for arsenic in the body or the level of arsenic present. They usually use urine or finger nail samples to perform these tests.

When it comes to drinking water, there are two types of removal technologies (treatment) that are available for at home installation (Table 3). Both **adsorption media** and **reverse osmosis** technologies can be installed to clean arsenic from water either before it enters your home (**point of entry**) or after it enters the home (**point of use**). If a private well supplies drinking or irrigation water, be sure to test it regularly for different contaminants such as arsenic. This is extremely important in areas with a known presence of arsenic in the rock formations or groundwater.

Arsenic Removal Technology	Description
Adsorption Media	Water that contains arsenic passes through a filter made out of metal (iron, alumina, zirconium, or titanium).
Reverse Osmosis	Water that contains arsenic passes through a fine filter (membrane) that does not allow the arsenic to pass through.

Table 3. Common arsenic removal technologies for the home.

To decrease arsenic exposure in the home, sources must be eliminated. Reduce the amount of dust that travels inside the home as well as the dust particles that may be suspended while cleaning (e.g. dusting and sweeping). One option might be to sweep or dust with a moist broom or cloth. In addition, wash hands frequently. This is especially true of children since they frequently place their hands in their mouths. Children also play with toys that have been on the ground, so make sure to thoroughly wash them after they are done playing with them.

If someone in the household comes into contact with arsenic due to their occupation or an outside activity, take precautions to decrease the introduction of arsenic containing dust or chemical in the home. Take off or change shoes before entering the home. It is also a good idea to shower and change clothes after work to further decrease arsenic exposure.

Outside of the home, arsenic exposure can be decreased or eliminated by reducing the use of arsenic containing pesticides (e.g. look for these chemical names on the label (monosodium methanearsonate and disodium methanearsonate). Residue from these products can eventually make it inside the home or can travel throughout the environment affecting animals and plants. Pressure treated wood contains a preservative that is made with arsenic (chromated copper arsenate). This preservative has been used on wood found in outdoor decks, furniture, and play sets. If you own products made with this type of arsenic treated wood, you should consider eliminating it. If you choose to do away with it, make sure that it is disposed of properly and not in your local landfill. Find

out where the nearest hazardous waste collection center is located that will accept this lumber by the local calling waste managements services.

Additional Resources

Web Resources – More Information on Arsenic

The “background” section in this module was developed to provide basic knowledge on the theme. In other words, important components and ideas are only highlighted and summarized. The purpose of this section is threefold: 1) provide additional sources of information in order to deliver an alternative way of looking at a theme, 2) expand the general information provided in the “background” to facilitate better training preparation, 3) offer potential training handouts or supplemental material that can also assist training participants. The brevity of the “background” section encourages the trainer to learning more outside of what is presented. The “background” section is a good jumping off point. Here are some suggested on-line resources that contain relative information, but please feel free to research others:

What is Arsenic? (Spanish/English)	University of Arizona	http://superfund.pharmacy.arizona.edu/content/informational-materials
Arsenic in Drinking Water (English)	U.S. Environmental Protection Agency	http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm
Arsenic (English/Spanish)	Agency for Toxic Substances and Disease Registry	www.atsdr.cdc.gov/toxfaqs/tf.asp?id=19&tid=3 http://www.atsdr.cdc.gov/es/toxfaqs/es_tfacts2.html/
ToxTown Arsenic (English/Spanish)	U.S. National Library of Medicine	http://toxtown.nlm.nih.gov/text_version/chemicals.php?id=3 http://toxtown.nlm.nih.gov/espanol/chemicals.php?id=35
Toxic Pollution in Water (English/Spanish)	Hesperian Foundation	http://en.hesperian.org/hhg/A_Community_Guide_to_Environmental_Health:Toxic_Pollution_in_Water http://es.hesperian.org/hhg/A_Community_Guide_to_Environmental_Health:Contaminación_tóxica_del_agua#Ars.C3.A9nico_en_el_agua_.E2.80.9Cpotable.E2.80.9D

Treatment Technologies for Arsenic Removal (English)	U.S. Environmental Protection Agency	http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=200171DW.txt
FDA Looks for Answers on Arsenic in Rice (English/Spanish)	U.S. Food and Drug Administration	www.fda.gov/ForConsumers/ConsumerUpdates/ucm319827.htm www.fda.gov/ForConsumers/ConsumerUpdates/ucm320572.htm
Arsenic in Food (English)	Dartmouth University	www.dartmouth.edu/~toxmetal/arsenic/food.html
Bottled Water: Pure Drink or Pure Hype? (English)	National Resource Defense Council	www.nrdc.org/water/drinking/bw/exesum.asp
Water On Tap: What You Need to Know (English/Spanish)	U.S. Environmental Protection Agency	http://water.epa.gov/drink/guide/index.cfm
Where is Arsenic Found? (English)	Agency for Toxic Substances and Disease Registry	www.atsdr.cdc.gov/csem/csem.asp?csem=1&po=5

Training Tools

Video Resources – More Information on Arsenic

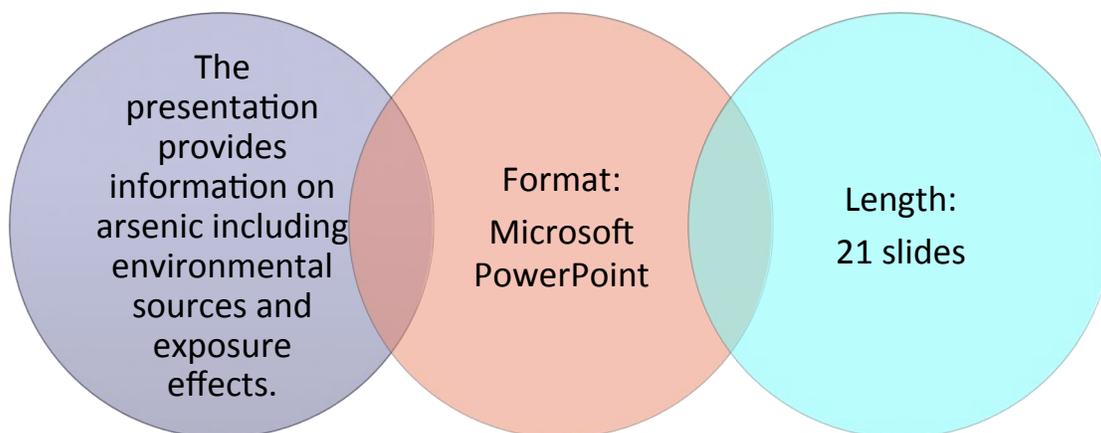
This section provides video suggestions that may help in preparation for the training or can be utilized as a training tool to help trainees understand theme concepts. Some of the videos can also be used as visual demonstrations when you are not able to set-up real-life activities. Here are some suggested video resources that contain relative information, but please feel free to research others:

In Small Doses (English)	Dartmouth University	www.dartmouth.edu/~toxmetal/InSmallDoses/
Arsenic Remediation in Nepal (English)	Dartmouth University	www.dartmouth.edu/~toxmetal/InSmallDoses/thayerarsenicremediation.html
Agua: Cada Gota es el Universo Parte III (Spanish)	Fondo Regional para la Cultura y las Artes del Noreste	www.youtube.com/watch?v=qUCaPyAzP8Y&hd=1

Introduction to Arsenic Mitigation (English)	U.S. Environmental Protection Agency	http://archive.org/details/gov.epa.816-c-05-005.1
Contaminación de Agua por Arsénico (Spanish)	cecilia maestriamx	www.youtube.com/watch?v=Z3zU1tstm7A&hd=1

Visual Aids – PowerPoint Presentation

The PowerPoint presentation provided is a prepackaged visual aid that can be utilized to train *promotores* on the respective theme of the module. It is meant to be adaptable and should be modified according to the audience needs and knowledge base. The information in the presentation is similar to that in the “background” section of this module. Certain terms and/or ideas may not be in the “background” section, thus a separate glossary is provided in this section to assist in defining.



Concept Glossary

- Bacteria, fungi, and some plants convert inorganic arsenic (toxic form) to organic arsenic (less toxic form) compounds. They do this chemically by gradually transforming it into a less toxic form of arsenic.
- The Borgias – They were Italian assassins during the 15th and 16th centuries that utilized arsenic to poison people. The goal of their assassinations was for to gain both politically and financially.
- Napoleon – He was been rumored to die of arsenic poisoning in 1821. Samples were taken of his hair and analyzed giving rise to the poisoning theory. Yet, this is a still debated theory.
- Arsenic and Old Lace – This is a play written in 1939 by American playwright Joseph Kesselring. In the play, the main character’s aunts have taken to murdering lonely old men by poisoning them with elderberry wine laced with arsenic, strychnine, and cyanide.

- Gallium arsenide – Fundamental component in the semiconductor industry. Items such as digital mobile phones, GPS navigation units, and wireless networks have driven demand for semiconductor devices.

Training Assessments and Extensions

- Have the *promotores* compare and contrast chronic and acute arsenic exposure health affects. They can take turns coming up to the board or easel pad to write down what they come up with. Also, have them discuss the differences between chronic and acute exposures.
- View the video “Agua: Cada Gota es el Universo” or “In Small Doses” and have them discuss maximum contaminant levels for drinking water when it comes to arsenic, what are the sources of arsenic contamination that are described, and arsenic toxicity health effects discussed.
- The *promotores* will identify the differences between inorganic and organic arsenic. They can take turns coming up to the board or easel pad to write down what they come up with.
- Brainstorm with the *promotores* how they will provide arsenic information to their clients, neighbors, or family. Sketch with them some of the messages or pieces of information that they found most important and can be easily translated to community members. Have them write on the board or easel pad some of these messages.

Concept Activities

These complimentary activities were designed to provide a hands-on component to the module trainings. They may be used to demonstrate a concept to visual learners or reinforce ideas presented to ensure comprehension. The activities have been divided into three sections (warm up, activity, and wrap up) in order to guide *promotores* through the concept(s). Also, some activities have “cheat sheets” for the trainer or handout materials that can be copied and handed out to the *promotores* at the training. Similar to other components in these modules, they may be adapted as needed considering training time, knowledge base, or available materials.

Activity 1. Arsenic, As Seen On TV

Materials

- Note pads (one note pad per *promotor* pair or group)
- Writing utensils (pencil or pen)

Warm Up

Ask the *promotores* to take a moment to think about the information that they have learned about arsenic. Have them jot down on a piece of paper some of the facts or pieces of information that they remember from the training. After they are finished, let them know that they will be developing public service announcements concerning arsenic. These announcements will be shown to people in their community on the local television channel.

Activity

1. Divide the *promotores* into pairs or groups.
2. Pass out the note pads and writing utensils to the different groups.
3. Inform the *promotores* that they will be developing two-minute public service announcements focused on arsenic. They can select whatever tone (e.g. humorous, serious, etc.) and information (e.g. only health, combination of drinking water and exposure routes, etc.) they feel appropriate for their community who will be watching them. Emphasis to them that they can be as creative as they would like, but they have to make sure to stay within the two-minute time frame.
4. Ask them the following questions in order to help them better deliver their message (they can briefly discuss them with their partner or group members):
 - a. Who are they talking too? Who is the audience they are targeting?
 - b. Why does this topic matter to this audience? Why should this topic matter?
 - c. What do they want them to “act on” when it comes to arsenic?
5. Have them start working on a draft script or layout of the public service announcement using the note pads you have provided them. Give them 10 minutes to develop their ideas.
6. When they have completed their scripts or layouts, have them come up to the front of the room and describe or act out their public service announcements.



Wrap Up

Ask the *promotores* what were their initial reactions to the public service announcements. Which public service announcement stood out the most to them? What information was most frequently provided? Discuss these and other questions that come up.

Activity 2. Arsenic Poisoning or Seasonal Flu?

Materials (Picture 1)

- Symptoms Cards: “Arsenic Poisoning” and “Seasonal Flu” set (make copies of each and cut along the dotted lines to make strips of each symptom)
- Envelopes (place the cut Symptom Cards into its own envelop and write on the inside flap whether the symptoms are for “Arsenic” or “Flu”)

Warm Up

Ask the *promotores*, “How many of you have ever been sick with the flu?” Explain to them that the flu (influenza) is a contagious respiratory illness that has affected everyone at one time or another (either by having had it or knowing someone who has had it). Tell the *promotores* that a virus causes the flu (influenza virus types A, B, and C), which is thought to spread mainly by droplets in cough, saliva, and sneeze.



Picture 1. Symptom cards and envelopes.

Activity

1. Tell the *promotores* that they will be “symptoms detectives” for this activity. Have them think about some of the symptoms they learned could result from arsenic poisoning in the training and some of the symptoms that they or others around them have experienced from the flu.
2. Ask the *promotores* for two volunteers who will be displaying the symptoms (patients).
3. Once you have the volunteers, have them come to the front of the room. Provide them with an envelope and tell them not to open them yet. Explain to them that in the envelopes they will find symptoms to either arsenic poisoning or the flu. They will be acting out the symptoms so the “symptom detectives” can guess if they are either sick because of arsenic or the flu.

4. Have the volunteers open the envelopes with the Symptom Cards and select the first symptom at random. They should act out the symptom simultaneously (or they can say it out loud if they can't act it out).
5. Next, have them again select another symptom and act it out or say it out loud.
6. After several iterations, check-in with the "symptom detectives" to find out if they have a clue which one is arsenic poisoning or the flu.
7. Continue this process until all the symptoms have been removed from the envelopes or the "symptom detectives" have confidently guessed which "patient" has arsenic poisoning or the flu.

Wrap Up

Have them discuss their observations of the symptoms for arsenic poisoning and the flu. Are the symptoms similar? Which symptoms are different?

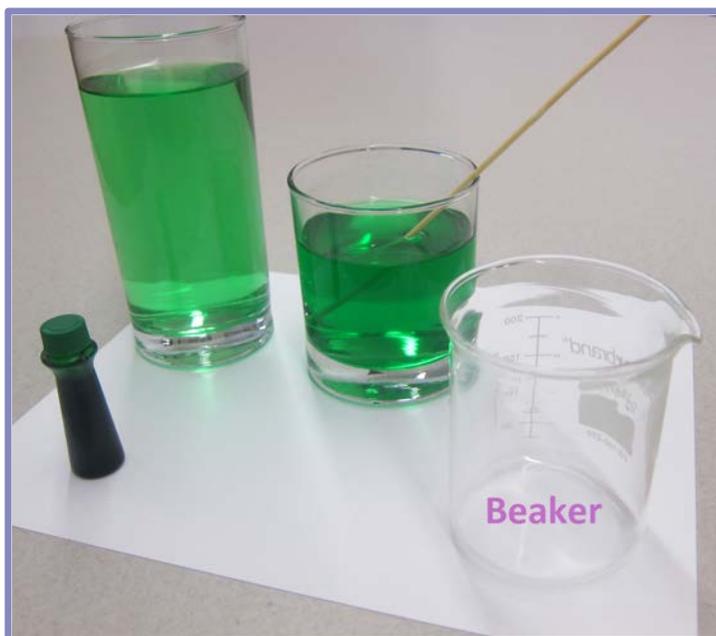
Activity 3. Who is exposed?

Materials

- 400 milliliter (mL) beaker (you can also use a large glass alternatively)
- 100 mL beaker (you can also use a small glass alternatively)
- 400 mL of water
- Food coloring
- Two stir stick
- One sheet of white paper

Warm Up

Remind the *promotores* that the main route of arsenic exposure in humans is water. Mention that there are studies under way that are evaluating exposure via food (rice, vegetables) and dust (**mine tailings**). Let them know that whatever the exposure route may be, an important part of the resulting health effects is susceptibility. This may include dose, duration, lifestyle, and genetics. Explain to them that the activity that they will be participating in will have them look at another important susceptibility factor, which is age (child versus adult).



Picture 2. Activity set-up using large and small glass as well as an example of a beaker.

Activity

1. Fill the 400 mL and 100 mL beaker about $\frac{3}{4}$ full with water (this would be 300 mL for the 400 mL beaker and 75 mL for the 100 mL beaker).
2. Tell the *promotores* that the 400 mL beaker represents an adult and the 100 mL beaker is a child.
3. Put the same amount of food coloring in each of the beakers (one or two drops).
4. Stir one of the beakers with one stir stick while the other beaker is stirred with the other stick.
5. Ask the *promotores* what they observe. Is there a color different (small beaker is darker while the larger one is lighter)?
6. Place the white sheet of paper behind the beakers to make it easier for them to see the color differences.
7. Ask them who is most affected? Why?

Wrap Up

State to the *promotores* that this is a demonstration on the importance of size or weight when it comes to human exposure. Repeat once again to them that children are most affected due to their size and weight.

Supplemental Materials

Seasonal Flu and Arsenic Poisoning Symptom Cards

Seasonal flu

(symptoms caused by Influenza Type A and Type B viruses)

- | Fever or Feeling Feverish/Chills
- | Cough or Soar Throat
- | Runny or Stuffy Nose
- | Muscle or Body Aches
- | Headache
- | Fatigue (Very Tired)
- | Vomiting
- | Diarrhea

Arsenic poisoning

(symptoms caused by acute poisoning via oral ingestion)

- | Stomach Pain
- | Vomiting
- | Headache
- | Throat Dryness
- | Difficulty Urinating
- | Dizziness
- | Nausea
- | Fatigue (very tired)

Supplemental Materials

Glossary

Adsorption media: water containing a contaminant passes through a filter made out of metal (iron, alumina, zirconium, or titanium) in order to be cleaned.

Arsenic: solid substance that is naturally found in the Earth's crust.

Carcinogen: ability to cancer causing.

Element: pure substance that cannot be separated into simpler substances by physical or chemical means.

Inorganic: substance that does not contain carbon.

Maximum contamination level: legal standard set by the United States Environmental Protection Agency determining the limit of a substance that is in public water systems.

Mine tailings: materials left over after mining of targeted ore/minerals. It is usually considered waste and uneconomic component consisting of rock, dirt, and water.

Organic: a substance that contains carbon or hydrogen.

Part per billion: value that represents one microgram per liter (liquid) or one microgram per kilogram (solid). Another way of looking at it is 1 part in one billion parts or one drop of ink in a large tanker truck (about 13,000 gallons).

Point of entry: placement of treatment system before water enters the home.

Point of use: placement of treatment system after water enters the home.

Reverse osmosis: water containing a contaminant passes through a fine filter (membrane) that does not allow the contaminant to pass through.

Semi-metal: nonmetallic element that is lusterless and solid and can transfer a certain amount of electricity and heat.